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REPORT

OF THE

SUPERINTENDENT

OF THE

UNITED STATES NAVAL OBSERVATORY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1900.

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SUPERINTENDENT OF THE NAVAL OBSERVATORY.

United States Naval Observatory,
Washington, D. C., October 16, 1900.

Sir: I have the honor to submit the annual report of the operations of the United States Naval Observatory for the fiscal year ending June 30, 1900.

Department of Astronomical Observations.

The work of the year in this department may be summarized as follows:

Prof. William Harkness, who retired from active service on December 15, 1899, was succeeded in the astronomical directorship by Prof. Stimson J. Brown, the senior professor of mathematics on duty at the Observatory. Professor Brown's first duty was as member of a board of examiners, to fill the vacancy caused by the retirement of Professor Harkness by the selection of a suitable candidate for appointment as professor of mathematics in the Navy. The labors of this board, of which Prof. William Hendrickson, U. S. N., was senior member, resulted in the selection and appointment of Prof. W. S. Eichelberger. In this connection it is pertinent to observe that the present condition of the astronomical staff of the Observatory is highly satisfactory, and gives promise for the future. The vacancies, caused by the rapid successive retirement of the older professors, have all been filled by young men of marked ability, and the Observatory has followed its traditional policy in this respect, and has every reason to anticipate a renewed activity and a period of harmony, industry, and usefulness.

All the astronomical instruments of the Observatory have been steadily and continuously in use during the year on every clear night and day.

The XXVI-inch equatorial telescope has been employed on the observation of difficult double stars, the satellites of the planets and the measurement of their disks, and on other objects suitable to an instrument of its power. This instrument was in charge of Professor Brown, assisted by Prof. T. J. J. See until December 15, and has since been in charge of Professor See.

In the month of October, during the hazy weather common at that season, the images of celestial bodies were marked by great steadiness in the field of view, unusual at other times. Owing to this favorable condition Professor See noticed on several occasions faint markings on the disk of Neptune, similar to the equatorial belts of the planets Jupiter and Saturn. The fine definition at this time was ascribed to the selective absorption of the haze caused by the smoke of forest fires, and an attempt has been made by Professor See and Mr. George H. Peters, the photographer, to reproduce artificially the same conditions by the use of a color screen. The idea of this application to the telescope was not wholly new, although it was believed to be so at the time. It is too early to speak definitely on the result of these experiments, except to say that the general effect of the use of a screen composed of two thin sheets of plate glass, the space between them being filled with a solution of chloride of copper and picric acid, or a solution of bichromate or chromate of potash, seems to have the effect of absorbing the blue rays and removing the halo which surrounds bright objects in the field of a large achromatic telescope, and the image appears somewhat steadied. The color screen is now in use in observations of the diameters of the planets and measurable satellites.

During the year the double floor, which was appropriated for last year, designed to obviate the difficulty experienced from currents of warm air rising from the basement, has been finished, and answers every expectation, giving highly satisfactory results.

The IX-inch transit circle was undergoing its periodical repairs and general overhauling from the beginning of the fiscal year until January 20, 1900, during which time the routine work of the sun, moon, and planets was carried on with the new VI-inch steel transit circle. Since the resumption of the regular work on the IX-inch circle, Professor Skinner has had charge of the zone observations and Professor Eichelberger of the routine sun, moon, and planet work, while the VI-inch circle, in charge of Professor Updegraff, has been under strict investigation, with a view to determining the causes of several faults made apparent by the routine work and probably unavoidable in a new instrument.

In the meridian work a total of 1,114 observations of zone stars and a total of 3,105 observations in the sun, moon, and planet work have been made during the year.

The XII-inch equatorial has been used for observations of comets, asteroids, and other miscellaneous objects, and will soon undergo extensive repairs and alterations.

Assistant Astronomer George A. Hill has devoted the prime vertical transit to observations of α Lyræ and a small list of suitable stars in the investigation of the variation of the latitude and the constants of nutation and aberration, and the same observer has used the new V-inch steel alt-azimuth instrument principally as a zenith telescope for observations for latitude by Talcott's method and for the declinations of stars of the American Ephemeris.

The 40-foot photoheliograph has been used in making daily photographs of the sun whenever the weather permitted, except after April 2, during preparations for the observations of the total eclipse of the sun on May 28.

By an appropriation of $5,000 the Observatory was able to undertake observations of the total eclipse of the sun on the date above mentioned. Two parties were sent into the field, and attention is respectfully invited to the detailed report of the astronomical director on this subject, and also to the recommendation for an appropriation to cover the expenses of a similar expedition this year, in the eclipse of May 17, 1901, which is approved and indorsed.

Preparations are now in progress for installing at the Observatory a new standard clock which shall be entirely freed from the influences of changes of temperature, and the recommendations of the astronomical director on this subject are approved.

The work of bringing up the publications of observations to date, which has been in arrears for several years, is being vigorously pushed, and the issue of the first volume of the new series of Washington observations, commencing with the first year of the observatory's work on the present site, will soon occur, to be followed by the succeeding volumes in rapid succession. The delay in the publication of its work has been made a reproach to the Observatory, although the causes of this delay have been reasonable and unavoidable, but the most earnest and determined effort is being made to relieve the observatory of a condition which has been used to its disadvantage in outside criticism.

The report of the astronomical director is herewith transmitted in full.

The department of magnetism has been discontinued, as noted in the last report of the superintendent. The buildings and instruments are, however, maintained in perfect order under the charge of Assistant Astronomer Theo. I. King. The Georgetown and Tennallytown Electric Railway has already installed a return wire which, it is reasonable to suppose, it intends sooner or later to use. When this road ceases to ground its powerful working currents, an attempt will be made to resume magnetic observations at the Observatory. The result is dubious. Moreover, the Observatory is to a lesser extent within the influence of the Chevy Chase road, which would continue to affect observations.

The following changes in the personnel of the Observatory have occurred during the year:

Prof. William Harkness was succeeded as astronomical director by Prof. Stimson J. Brown, the senior professor of mathematics, in December, 1899.

Prof. Milton Updegraff reported for duty July 15, 1899; was assigned to duty in the astronomical department.

Prof. W. S. Eichelberger, a former computer, was appointed after a competitive examination; he reported for duty February 17, 1900, and was assigned to the astronomical department.

Computer J. C. Hammond was transferred from the Nautical Almanac Office to the Observatory February 20, 1900, and was assigned to the astronomical department.

Department of Chronometers and Time Service.

I invite the attention of the Bureau to the recommendation of the head of the department of chronometers and time service, and of the department of nautical instruments and general storekeeper, in which I concur. These two departments should be under separate heads. The estimates for the next year show one stenographer and typewriter submitted for general clerical service at the Observatory. Should this estimate be granted, the clerk who now assists in the work of the general storekeeper could give more time to that duty; but the estimate of the head of the department is not excessive. I believe that the Observatory is the only station at which the general storekeeper system prevails which is allowed no assistance whatever—clerical or otherwise. As the work of this department must and should be kept up, as it forms an increasingly important part of the general functions and usefulness of the Observatory as a naval establishment, a computer from the astronomical department has been assigned to assist in the time service and the clerk of the Observatory to assist in the accounts of the general storekeeper. This expedient can be regarded only as temporary. When the public service require work to be done, it is not unreasonable on the part of those charged with its execution to request the means of doing it.

An objection to the present arrangement exists in the danger that the continuity of work in the general storekeeper's department may at any time be seriously interrupted by the sudden detachment of the Navy officer in charge. There should be a permanent force of assistants in this office. It has occurred to me to suggest that the Department might reasonably consider the assignment to duty at the Observatory, under the provisions of the naval act of this year, of one or more retired line officers of suitable age and tastes for the departments of chronometers and time service, and of nautical instruments, and as subordinates to the active head of those departments.

Grounds and Roads.

Since my last report the offer which I therein noted to purchase a certain tract of the Observatory land lying outside the proposed Observatory circle has been withdrawn, owing to the doubt as to the projected grade of Massachusetts avenue extended. The settlement of this question seriously threatened the interests of the Observatory property. Acting under the instructions of the Department, I have, from time to time, conferred with the District Commissioners, with the result that the understanding has been reached that no steps would be taken detrimental to the Observatory without my being informed. I believe this question will be settled without prejudice to the Observatory's interests, and I renew my recommendation that no land lying outside the proposed Observatory circle be sold, except possibly the tract which was the subject of negotiation last year. This would not preclude the acquisition, by purchase, of lands lying within the proposed circle should the extension of roads, etc., in the neighborhood make it desirable to add them to the Observatory domain.

Board of Visitors.

As noted in my last report, and for the first time in its history, a board of visitors was appointed which visited the Observatory in June and again in September, remaining a few days at each visit. As the report of the board, which was not made available to the Observatory until long after its substance had appeared in the public prints, was in the nature of an attack on the Observatory, I trust that it will not be out of place, in the report of the Superintendent, to touch upon its salient features.

The board was unfortunate in having the support of several zealous newspaper writers, by whom it has been made to appear, and I think that it is generally believed in the scientific world and by that part of the public which takes an interest in scientific affairs, that the presence of the board was in the nature of a visitation distasteful to the Observatory and inflicted against its will. As the Observatory has thus been made to appear in an odious light, I take the liberty of reminding the Bureau that not only the original conception of the board of visitors was a suggestion of the Superintendent, but the selection of the three astronomical members was concurred in by him because they were already the members of a self-constituted committee to conduct a gratuitous investigation of the Observatory, and known to be inspired by a hostility to its organization. It was hoped that by placing them in a position of official responsibility an impartial judgment could be obtained.

A criticism of the report may be very briefly summarized. The board made no examination or inspection of the Observatory except in the most casual way. To quote its own language, "Owing to the lack of printed material representing the recent work of the Naval Observatory, the board of visitors finds it practically impossible to form a satisfactory opinion of that work without devoting to the task an inadmissible amount of time and labor." Nevertheless, and without such an opinion, the board did not hesitate to recommend the most sweeping changes in the present organization, and it is noticeable that the report of the board deals exclusively with the question of reorganization, while that question had not been officially presented to it at all. As a guide to the board the following letter of instructions was addressed to it by the Department:

NAVY DEPARTMENT,
Washington, June 28, 1899.

SIR: I have the honor to inclose you herewith a memorandum making certain suggestions which the Department wishes the board, of which you are the chairman, to have in mind in making an examination of the Naval Observatory. This memorandum is not intended to finally limit the investigations of the board, but to convey certain suggestions in regard to which the Department desires to be informed, and which, it is believed, may assist the board in its work.

JOHN D. LONG, *Secretary.*

Hon. WM. E. CHANDLER,
Chairman Board of Visitors, Naval Observatory, Washington, D. C.

MEMORANDUM RESPECTING THE FUNCTIONS OF THE PROPOSED BOARD OF VISITORS TO THE NAVAL OBSERVATORY.

The board of visitors is authorized to examine the equipment and working of all parts of the Naval Observatory and to make any suggestions which may seem desirable for improving the scope and efficiency thereof, but in so doing the following facts should be borne in mind:

1. Perhaps the most important astronomical duty of the Government is the publication of a nautical almanac, and as that is intended not only for the use of navigators, but also for the guidance of astronomers in the most delicate investigations known to their science, it should evidently be kept up to the highest attainable pitch of accuracy. To that end a continuous series of meridian observations upon the sun, moon, planets, and stars is absolutely necessary, and as such observations upon the sun, moon, and major planets are practically confined to the Government observatories at Greenwich, Paris, and Washington, the necessity for making them the primary work of the Naval Observatory hardly seems open to discussion. The importance of observing satellites in order to determine the masses of their primaries is evident, and in that connection the question of providing the Naval Observatory with a large heliometer may well be considered.

2. As a secondary object, the Naval Observatory has always found it possible to make many observations of asteroids, comets, and double stars, and it has recently obtained spectroscopic apparatus for investigating the motions of stars in the line of sight; but the board might well consider how far such secondary work should be extended, and whether or not it is desirable to obtain a 13-inch photographic telescope for the purpose of mapping more or less extended portions of the heavens.

3. The needs of the Navy necessitate the testing of a large quantity of instruments to be used at sea, among which chronometers occupy a very prominent position. The processes employed have gradually grown up at the Naval Observatory, and as there is very little precedent for most of them, the opinion of the board on their scope and thoroughness would be valuable.

4. The operations of the electric street railways in the vicinity of the Naval Observatory have interfered so much with the continuous magnetic observations

formerly made there as to cause their suspension. In view of the small number of magnetic observatories in North America, this seems so serious a loss to science that the board might well consider whether or not anything can be done to remedy it.

5. In the opinion of those responsible for the management of the Naval Observatory, its most serious defect at the present moment is the backwardness of its publications, but that has arisen through circumstances which were hardly avoidable, and which are not likely to recur in the future. The equipping of a new observatory, and the observation of the zone of stars lying between 13° 50′ and 18° 10′ of south declination for the international catalogue of the German Astronomical Society, while at the same time the series of meridian observations upon the sun, moon, and planets was continued as usual, rendered it impossible for the limited staff to keep the reductions up to date. If work is continued on the present lines, it is believed that these arrears can be brought up in about three years, and after that it should be possible to have each annual volume appear within about eighteen months after the date of the last observation it contains. As the removal to the new Naval Observatory may naturally be regarded as marking the beginning of a new series of publications, the board might well consider whether or not any changes are desirable in the forms adopted for printing the observations.

Not one of the subjects proposed in the above memorandum received the attention of the board or was even mentioned by it. The whole report is taken up with the proposed reorganization, a subject which it had not been asked to consider at all, and for which it could only find a general authorization in the concluding paragraph of the Department's letter.

Notwithstanding that the board had no time to form an opinion as to the condition of work at the Observatory, the conclusion upon which it bases a recommendation for a revolutionary change of organization is found in the charge that the output, in published results, is not commensurate with an extravagant annual outlay. In other words, the board lays particular stress upon the delay in the publication of the annual volume, and bases its whole finding upon that fact.

The board makes a comparison between the Naval Observatory and the observatories at Greenwich and Harvard, selecting the former because it is supposed to cover nearly the same field, and the latter because it also undertakes large pieces of routine work which are beyond the reach of smaller observatories, because the resources of Harvard approach more nearly than do any other those of the Naval Observatory, and because all the details of the Harvard Observatory were readily available, its director being a member of the board.

I ask the attention of the Bureau to the following table, which gives an exact comparison of the three observatories chosen by the board, and which, almost without elucidation, confutes the sole and only charge made by the board against the efficiency of the Observatory upon which charge the only recommendation of the board rests.

Comparison of number and cost of scientific personnel of Greenwich, Harvard, and Naval observatories, previous to July 1, 1900:

GREENWICH OBSERVATORY.

Scientific personnel.	Number.	Average.	Total.
Director	1	$5,000	$5,000
Chief assistants	2	2,550	5,100
First-class assistants	4	2,000	8,000
Second-class assistants	4	1,200	4,800
Magnetic superintendent	1	1,700	1,700
Assistant magnetic superintendent	1	1,000	1,000
Computers	23	325	7,475
Total	36	....	33,075

HARVARD COLLEGE OBSERVATORY.

Scientific personnel.	Number.	Average.	Total.
Director	1	$5,000	$5,000
Astronomers	6	2,000	12,000
Assistant astronomers	13	900	11,700
Computers	18	600	10,800
Total	38	....	39,500

UNITED STATES NAVAL OBSERVATORY.

Scientific personnel.	Number.	Average.	Total.
Astronomical director	1	$3,500	$3,500
Other professors of mathematics	4	2,700	10,800
Assistant astronomers	3	1,900	5,600
Computers	6	1,200	7,200
Photographer	1	1,200	1,200
Total	15	....	28,300

A comparison of the figures in this table shows that the number of astronomers employed at the Naval Observatory is 5, at Greenwich 3, at Harvard 7. The Naval Observatory has the advantage of Greenwich and decidedly the disadvantage of Harvard. In the matter of assistants, however, the case is different. The total of assistants at Greenwich is 8, at Harvard 13, and at the Observatory 3; while the computers stand, Greenwich 23, Harvard 18, Naval Observatory 6.

In the years 1891 to 1893 the Observatory was removed from the site which it had occupied for nearly fifty years, to its present situation. The delays in building, the labor of dismounting and remounting the instruments, the repairs and alterations of the same and their subsequent installation, the removal of the records and Observatory property, and generally the labor involved in settling in the new place, absorbed the entire time of the whole very limited working force of the Observatory for several years. The publication of results, from this cause and from this cause alone, fell into arrears. The force of the astronomical staff, sufficient for current work in settled times, was totally inadequate to bring up back work when the work had fallen behind. It was simply a physical impossibility to keep up the publications, and to make the current observations and do the necessary work of removal at the same time. This and this alone is the cause of the delay in printing, and when the number of assistants and computers at the Observatory is contrasted with the numbers at Greenwich, and especially at Harvard, the delay is reasonable on its face. These facts were represented to the board, but are nowhere given in its report. The board, on the contrary, evaded and concealed them. It might have reasonably been shown that during the whole of this transition period current work was practically uninterrupted, and that the number of observations made at the old and new observatories kept pace with those made at Greenwich. But "owing to the lack of printed material the board found it impossible to form a satisfactory opinion upon that work, without devoting to the task an inadmissible amount of time and labor." The facts were laid before the board and ignored by it. They would have shown to the credit of the Observatory.

It is needless to say that the figures in the above table are not given by the board in its comparison of the three observatories named as they are given here. The board had to make a case against the Observatory, and the charge of extravagance of outlay in proportion to the output of results had to be substantiated. Accordingly the whole staff of the Observatory, scientific and lay, is contrasted with that at Harvard, and the numbers are brought to an equality by adding in the artisans and laborers employed about the buildings and grounds, Harvard having practically none. By this process the astronomical personnel of the Observatory is shown to be one in excess of that at Harvard, and the salaries are compared on this basis, greatly to the disadvantage of the Observatory. This enumeration also charges the Observatory with two "directors" for the same obvious reason. Although the board had no time to form an opinion, it should have learned, if it could have assimilated the information which it received, that the Observatory, like other naval establishments, has but one "head," and that the astronomical director of the Observatory is the head of the astronomical department, just as a naval officer is the head of the department of nautical instruments. To charge two "heads" to the Observatory in order to increase the apparent extravagance of maintenance is clearly a perversion of fact. If the Observatory has two heads then it has eight heads, one for each department, and including the superintendent.

The attention of the Bureau is asked to a comparison of salaries, shown in the above table, which forms the basis of the board's charge of extravagance. At both Greenwich and Harvard the salary of the director is $5,000. At the Observatory, using the board's own method of comparison, the corresponding salary is $3,500. But, by the ingenious device of a "dual head," the board increases it to $4,000 and then doubles it. Naval officers receive their pay, whether they happen to be on duty at the Observatory or elsewhere; but the board chooses to assume that the salary of every professor of mathematics in the Navy, active or retired, except two at the Naval Academy, is chargeable to the expenses of the Observatory. It therefore charges in its exhibit the salaries of officers on the retired list, and the salary of one officer, still on the active list, whose connection with the Observatory has long since definitely ceased for cause. By such flimsy expedients as these the expense column is easily swelled. It might be swelled to any amount desired by simply charging against it the salary of any or every living officer of the Navy, active or retired, who had ever been on duty at the Observatory. It is in the lower grades particularly, however, that I ask a fair comparison of salaries at the three institutions selected by the board. At Greenwich, for example, computers receive an average of $325 per year, less than one-half the pay of our laborers, and less than the remuneration of any human being doing skilled work in the United States. At Harvard computers receive an average of $600, less than the pay of any person in the United States Service. These computers are largely women, who can be got to work for next to nothing. Now the Observatory pays its employees at exactly the same (or in some cases less) rate as in other branches of the Government Service in corresponding grades. To charge extravagance against the Observatory because its employees are paid according to a rate fixed by law for the public service at large is clearly disingenuous and tending to mislead.

The whole report of the board is colored by the evident intention of making as strong a case against the Observatory, and in favor of its own plan of reorganization, as possible.

On page 6 the board objects to transferring responsibility of direction from the astronomical director to a committee, and then, on pages

7 and 8, recommends that the board of visitors "shall prepare and submit to the Secretary of the Navy regulations prescribing the scope of the astronomical and other researches of the Naval Observatory and the duties of its staff with reference thereto." In other words, the duties which should belong to the astronomical director, if he is to be held responsible for the astronomical work of the Observatory, are to be transferred to the board of visitors. Furthermore, on page 14, it is proposed that the board of visitors shall have power to make "necessary changes," apparently not only in the work but also in the personnel.

On page 8 objection is made to retiring astronomers at 62 years of age, as is now done, and on page 6 it is specifically recommended that under the proposed new arrangement the astronomical staff of the Naval Observatory are "to hold their offices until their successors are appointed," or, in other words, they are to have no tenure of office at all, and to be liable to dismissal at any moment.

The pay table on page 9 proposes to give the Astronomical Director $6,000 a year, and the Director of the Nautical Almanac, $5,000, making a total of $11,000 a year, for the same duties which were then performed by Professor Harkness for $3,500 a year. In view of the distinct charge of extravagance against the present administration, this proposal is only ludicrous. It is difficult to believe that it was intended to be taken seriously.

On page 12 it is asserted that the 9-inch transit circle was not then in use, although the board knew that it was simply undergoing periodical temporary repairs, and would be brought into use again as soon as they were completed.

On page 13 it is asserted that none of the directors of the Greenwich or Harvard College observatories "have ever resigned to accept positions elsewhere," but the author of the report forgets to mention that one of the Greenwich astronomers royal did resign.

On page 15 it is indirectly stated that when an observer is not actually observing he is only doing clerical work, which is untrue. The reduction of astronomical observations is not clerical work within the ordinary meaning of that phrase.

The statement on page 30 respecting the personnel of the Observatory board established by Rear-Admiral John Rogers is wholly erroneous. That board comprehended the entire astronomical staff of the Observatory.

In the list of professors of mathematics, given on page 41, Prof. H. M. Paul is stated to be attached to the Naval Observatory when in fact he is attached to the Bureau of Yards and Docks.

An historical sketch of the Naval Observatory, written by an individual member of the board, with the avowed purpose of showing that the system under which the Observatory has been administered since its foundation is entirely defective, is appended to the report. It is a sufficient criticism of this sketch to say that a system which, from a most modest beginning, has built up one of the few great astronomical institutions of the world, and which has produced the two most eminent living astronomers in America, can not be wholly bad.

It is particularly worthy of note that the board actually proposes to remove the affairs of the Observatory from Government control. The irresponsible governing authority of a public institution is to be "a board of visitors independent of Government control, but having power to make necessary changes." With the exception of this preposterous proposal, I will dismiss the plan of reorganization proposed by the board with the simple statement that subsequent events have made it impracticable, or at least highly unlikely to be seriously considered now. To apply it at the present time would be, not to build up, but to tear down.

A determined effort was made by the board to prevent, if possible, the appointment of new men to fill the vacancies created by the retirement of the older professors of mathematics at the Observatory. New offices were created in the board's plan of reorganization at enormous salaries. Notwithstanding the efforts of the board to prevent it, these vacancies have all been filled in line with the traditional policy of the Observatory, which has always been to take for its staff young men of promise whose career was before them, in contrast with the plan recommended by the board of appointing at once to high office men whose scientific reputation was already established, and whose prejudices and animosities were mature and confirmed.

I have ventured to touch in brief upon the report of the board of visitors in a manner which I trust does not transcend the legal limitations of this report, because, while the Observatory has been made the object of adverse criticism in the report, the friends and supporters of the board have not hesitated to assail it in attacks in the public prints, some of which have been extremely abusive and obviously dictated by pure malice, and with the knowledge that a reply in kind was impossible. This report furnishes the only means of replying to these attacks, which are and have been perennial, culminating in force whenever, as in the present instance, circumstances seemed to justify a reasonable anticipation of success.

The Observatory staff is now complete. The excuse afforded by the retirement of the older professors of mathematics no longer exists. For the present, at least, no person, no matter how eminent he may be in science, can pretend to be a friend of the Observatory or of science while attacking its organization. I do not mean to say that the Observatory should be exempt from criticism; but such criticism, in order to be of any benefit, must be made in a spirit of fairness, and not in a spirit of animosity. The Observatory invited such criticism from the recent board of visitors, and its invitation was slighted.

The observatory is making an earnest and honest effort to correct faults which have, in most cases, arisen from circumstances not wholly within its own control, as the board very well knew, but omitted to point out. It is only reasonable to ask that it be allowed a fair field for its efforts.

The experience with the recent board of visitors was not such as to encourage the hope that much good can be gained by a repetition of the experiment. Nevertheless, I recommend that a board of visitors be appointed from time to time, as may be convenient to the Department, not to act in an arbitrary and irresponsible capacity of authority, "free of government control," as recommended by the late board of visitors, but to give the observatory the benefit of its counsel and to give the scientific world an insight into the actual workings of the institution.

NAUTICAL ALMANAC.

The report of the Director of the Nautical Almanac is herewith transmitted.

LIBRARY.

Assistant Librarian William D. Horigan has direct charge of the library, under the general supervision of the library committee.

	Volumes.	Pamphlets.	Total.
Contents of the library July 1, 1899	17,050	3,736	20,786
Accessions	550	81	631
Contents July 1, 1900	17,600	3,817	21,417

Of the accessions, 377 were received as exchanges and 254 were purchased.

I am, sir, your obedient servant,

C. H. Davis,
Captain, U. S. N., Superintendent of Naval Observatory.

The Chief of the Bureau of Equipment,
Navy Department.

United States Naval Observatory,
Washington, D. C., August 13, 1900.

Sir: In compliance with paragraph 23 of the regulations for the government of the United States Naval Observatory, I have the honor to submit the following report concerning the operations of the astronomical department for the fiscal year ending June 30, 1900.

This department was in charge of Prof. William Harkness, U. S. N., until December 15, 1899, at which time he was relieved by myself preparatory to his retirement on December 17.

Upon assuming the duties of astronomical director my time was largely occupied for a month as a member of a board conducting a competitive examination for filling vacancies in the corps of professors of mathematics in the Navy, and in acquainting myself with the conditions of the work and instruments in this department.

On January 16 a more efficient distribution of the personnel engaged in the routine transit circle work, which had up to that time been in charge of Professor Skinner, assisted by a force of observers, including professors, assistant astronomers, and computers, was undertaken with the view of gradually utilizing more fully the available observing time of all the instruments. Professor See had been assigned the charge of the 26-inch equatorial on December 18, 1899, and Professor Updegraff to the charge of the 6-inch steel transit circle. The routine observations were, however, necessarily continued on this instrument in charge of Professor Skinner until the 9-inch transit circle should be in a condition for use. On January 16, 1900, the routine work on sun, moon, and planets was transferred to the latter instrument, with Professor Skinner in general charge of the instrument and observations; the observations and reductions of the revision zones to be carried on by Professor Skinner and Assistant Astronomer King; and the routine observations and reductions of the sun, moon, and planets by Professor Eichelberger, assisted by Computers Boeger, Brown, Lawton, and Hammond. Assistant Astronomer Littell was transferred to the 6-inch transit circle on February 7.

THE 26-INCH EQUATORIAL TELESCOPE.

[Prof. T. J. J. SEE, U. S. N., in charge.]

On December 15, 1899, Professor See was placed in charge of the work on the 26-inch equatorial, which up to that time had been in charge of Professor Brown. It has been devoted throughout the year to the same general lines of research as in the past, consisting of observations of difficult double stars, satellites of the planets, and other objects suitable to a telescope of its optical powers.

Observations of close and difficult double stars have been made only on exceptionally favorable nights, while on less favorable nights easier pairs have been selected. One hundred and fifty measures of such objects have been secured by Professor See and twenty by Professor Brown. An orbit of τ Cygni, which revolves in a period of fifty-seven years, has been deduced by Professor See from available measures since 1874, and an approximate orbit of 95 Ceti, from which it appears that the period of revolution is about one hundred and fifty years, a much longer time than has hitherto been supposed. Both have been published in the Astronomische Nachrichten No. 3629, as well as a correction to Professor See's orbit of β 395, deduced from measures on two nights, indicating that the period will be reduced to about fourteen years, which, if verified, makes this object one of the most rapid of visual binary stars. Professor See also announces in the same number of the Astronomische Nachrichten 3629, the observation on December 8, 1899, of the duplicity of 13 Ceti. This system has evidently made nearly half a revolution since Hough's discovery and earlier work in 1887, and is probably an important binary. The faint companions of Sirius and Procyon have also been measured and the results communicated to the Astronomische Nachrichten.

The experience of the past year in this line of work confirms that of the past few years, and shows that the theoretical limits of the object-glass can be obtained on the best nights, but the amount of fine weather in Washington is much less than can be had in other places with more favored climate. The installation of the insulating covering of the basement floor, spoken of in the last report of the astronomical director, has undoubtedly improved somewhat the unfavorable conditions for observing in cold weather, as it certainly has the usefulness of the instrument in making possible its use in the coldest weather of winter.

Observations of Neptune's satellite were secured on sixty-five nights, between October 6, 1899, and February 27, 1900. These measures have been reduced and compared with the elements of that satellite resulting from Professor Brown's previous investigations, to which they furnish slight corrections. The reduction and discussion of the observations was carried out mainly by Computer John C. Hammond, as a voluntary labor outside of his official duties, and the observations and results will shortly appear in the Astronomische Nachrichten, to which paper they have been sent for publication.

Observations of the two outer satellites of Uranus—Oberon and Titania—were begun on April 25, and have been continued on every night when they were visible. Up to July 1 only 20 observations have been secured, as, owing to the extreme southerly declination of the planet, the satellites can not generally be seen during the week preceding and following the full moon. The two inner satellites were occasionally glimpsed, but they could not be satisfactorily measured owing to their faintness.

Observations of the four brighter satellites of Saturn—Titan, Rhea, Dione, and Tethys—were begun on May 5. Up to July 1 measures of Titan, referred to Rhea, were secured on 22 nights, and of Dione, referred to Tethys, on 15 nights, the relative positions of the satellites being measured in pairs, in order to avoid referring them singly to the center of the irregularly shaped planet.

During the hazy weather common here in the month of October, resulting in giving great steadiness to the images of celestial bodies, unusual at other times, Professor See noticed on several occasions some very faint markings on the disk of Neptune, which were ascribed by him to equatorial belts similar to those long known on Jupiter and Saturn. The fine definition at this time, aside from the steadiness of the image, was ascribed to the selective absorption of the haze caused by the smoke of forest fires, and experiments were carried out by Professor See and Mr. G. H. Peters to attain the same end artificially by the use of a color screen.

As a final result of the experiments three color screens were constructed by Alvan Clark & Son from designs by Professor See. The small cell consisted of two thin plates of plane parallel glass cemented to either side of the glass ring separating them, and the whole fitted in a brass adapter so as to bring it just outside of the outer lens of the eyepiece. Various fluids were used as absorbing media, depending upon the object to be attained, but generally such as to remove the blue rays, for which the telescope is imperfectly corrected, causing a troublesome violet-blue halo around all bright objects. On Mercury, Venus, Jupiter, Saturn, Uranus, and Neptune a solution of picric acid and chloride of copper in water was found most satisfactory, as it absorbs largely the red rays as well as the violet-blue. A solution of the bichromate or chromate of potash also performs well on bluish planets like Uranus and Neptune, and fairly well on Mercury and Mars. A preliminary account of the color screen was published in the Astronomische Nachrichten, No. 3636, and at the time it was supposed the experiments and results were entirely new. The editor of the Nachrichten, however, in an editorial note calls attention to similar experiments made in 1883 by Professor Mittenzwey, using as an absorbing medium a derivative of resorcin, known technically as fluorescein. His research was apparently carried no further than the experimental stage, sufficiently to demonstrate the practical advantages of the color screen in observations with large achromatic telescopes, and appears to have since remained unnoticed until the publication of the experiments and results in the Astronomische Nachrichten of April, 1900.

When the light is transmitted through the absorbing fluid, in addition to the removal of the violet-blue halo resulting from uncorrected chromatic aberration the image is somewhat steadied and the limbs of the planets thereby considerably sharpened. On account of these advantages measures of the diameters of the planets and measurable satellites have been made, excepting Mars, and it is proposed to continue the investigations during the present year.

The resulting diameter of Neptune, from measures on four nights, indicate a diameter of 2″.00, which is considerably less than recent measures with telescopes of large dimensions. The diameter found by Professor Barnard with the Lick 36-inch telescope is 2″.43, and by Prof. Hermann Struve with the 30-inch Pulkowa telescope is 2″.19.

Professor Struve's result, which is the smallest value heretofore obtained, was derived from a series made with field illumination of different colors, by which the effect of the secondary spectrum would to a certain degree be removed.

Measures of the diameter of Uranus on 22 nights, with the color screen give a result of 3″.30 ± 0″.005, which is also smaller than recent results with large telescopes. Professor Barnard's value of this diameter, determined at the Lick Observatory, is 4″.15, and he also finds a considerable ellipticity of figure. With the observations of the Washington telescope the disk was always found sensibly round, an oblateness of one eighty-third being indicated, which is probably not real.

A large number of observations of the diameters of Jupiter and Saturn have been made, and the series is to be continued throughou the present and during the next opposition.

Measures of the diameter of Venus have been secured on 17 days near inferior conjunction. The effect of the color screen in improving the definition in observations made in daylight is quite as decided as in observations at night.

Observations of the diameters of Jupiter's satellites indicate, as in the case of Neptune and Uranus, a considerable reduction of the measured diameters. How much of this decided tendency, which affects apparently only objects of small diameter, may be due to personal equation or to the absorptive effect of the color screen, can not be determined until comparisons shall have been made with observations without its use, and also with observations with the same device by other observers with instruments of suitable power.

All observations of double stars made by Professor Brown from 1896 to December 17, 1899, have been collected and published in the Astronomische Nachrichten, Nos. 3645–3646.

But little work was done with the spectroscope during the last fiscal year, as the previous investigations had shown the necessity for considerable alteration of the apparatus before it would give results suitable for the delicate investigations for which it is intended. The two new triple lenses for the camera and collimator were received from Mr. Brashear on March 23, and a few photographs taken to test their performance. Unfavorable weather and the demands of preparation for the observations of the eclipse of May 28 prevented any work beyond preliminary trials for the focus of these lenses.

THE 9-INCH TRANSIT CIRCLE.

[Prof. A. N. SKINNER, U. S. N., in charge; Prof. W. S. EICHELBERGER, U. S. N., in charge of sun, moon, and planet work.]

This instrument was undergoing repairs and alterations from the beginning of the fiscal year until January 20, 1900, during which time the routine observations of sun, moon, and planets were carried on with the 6-inch transit circle. The repairs consisted of recutting the faces of the marble piers supporting the instrument, rebuilding the nadir box, moving the west pier north twenty-five one-hundredths of an inch to bring the azimuth screws to the middle of their adjustment, and the mounting of the lanterns for illuminating the microscopes and telescope either by electric or gas light.

Although there yet remained other important changes which ought to have been made, the experience with the 6-inch transit circle had indicated equally the desirability of minor alterations and investigations of some peculiarities in order to make its performance satisfactory, and the work on the sun, moon, and planets was therefore transferred to the 9-inch transit circle on January 20, 1900.

This instrument is, in its essential features, the old Pistor & Martin's transit circle used in the old Observatory from 1866 to 1892, but in the attempt to improve it by extensive alterations the importance of providing a symmetrical illumination in the place of the old one appears to have been entirely overlooked. The unsymmetrical illumination of the field, which seems to be one of the few objectionable points of the Pistor & Martin's instruments, not only produces liability to systematic errors in both right ascension and declination, but also introduces liability to errors in the determination of the constants and of observations of stars, which, although small, ought not to be tolerated in a modern instrument. With this feature of the instrument remodeled, as it can be at comparatively small cost, it will be in a condition for any kind of observations which may be required of a meridian circle. As the errors may be partially avoided by the exercise of careful precautions, it will continue to be actively used until a more favorable time than the present arrives for its repairs.

Upon the resumption of the regular work (in order to expedite the completion and publication of the Southern zone), Professor Skinner was placed in charge of the zone work, to which, with the assistance of Assistant Astronomer King, he will devote all of his time. Professor Eichelberger was placed in charge of the routine sun, moon, and planet work on the same instrument, assisted by Computers E. A. Boeger, W. M. Brown, G. K. Lawton, and J. C. Hammond, and until February 7 by Assistant Astronomer Littell. At the same time some changes were introduced in the general method of carrying on the routine observations and reductions by which the flexure will be taken into account in deriving the equator point from which the differential declinations will be determined. In the determination of this constant in the daytime there is frequently a wide range of declination in the fundamental stars used for this purpose, and unless the equator point thus derived is corrected for flexure there will be liability of the introduction of systematic errors.

ZONE OBSERVATIONS —13° 50′ TO —18° 10′.

During the year the observations of zone stars have been confined to a revision of the zones previously observed, in order to explain or correct discrepant results. The number of observations made during the year is as follows:

Zone stars	910
Zero stars	204

It is expected that the revision observations will be completed before December 31, 1901. The reductions of the zone observations to 1900 have been completed and the results entered in the card catalogue. The results have been inspected for discrepancies, and discrepant stars have been selected for reobservation. The reduction of these revision observations is kept as close as possible up to date, in order to bring this part of the work to an end as early as practicable. With the force of computers now available it is hoped that the first volume of zone observations will be ready for the printer by January 1, 1901.

SUN, MOON, AND PLANET WORK.

The following table shows the number of observations of each object on each instrument during the year ending June 30, 1900:

	6-inch transit circle.	9-inch transit circle.	Total.
Ephemeris stars	1,345	843	2,188
Sun	93	52	145
Moon	89	65	154
Mercury	43	29	72
Venus	69	49	118
Jupiter	....	6	6
Saturn	6	3	9
Uranus	3	4	7
Neptune	20	....	20
Miscellaneous stars	73	....	73
Wire interval stars	158	78	236
Longitude stars	....	77	77
Total	1,899	1,206	3,105

The reductions are completed through March, 1900. The copy for the printer is completed through June, 1898, and the copy for 1899 will be in the hands of the printer before October 1, 1900.

THE 6-INCH STEEL TRANSIT CIRCLE.

[Prof. Milton Updegraff, U. S. N., in charge.]

As stated in the paragraph concerning the 9-inch transit circle, the routine observations of the observatory were carried on on this instrument from July 1, 1899, to January 20, 1900, in charge of Professor Skinner. On December 18, 1899, Professor Updegraff was assigned to the charge of the instrument to give such time to the investigation of it as was possible without interfering with the routine work.

The experience gained in the observations, as well as their final results for the preceding portion of the year, had shown that the instrument, owing to lack of sufficient investigation and preliminary observations was hardly in a condition to use for the routine work of the observatory. There had been developed the necessity of various repairs and alterations in the instrument and its accessories, as well as a more careful and extensive investigation of its performance than was feasible while using it for daily work on the sun, moon, and planets. The repairs and alterations, although principally of a minor character, were numerous and required considerable time, while the investigation to test its suitability for work of the highest accuracy must necessarily be extensive. The necessary observations for this purpose have been laid out with the object of securing as far as practicable results of immediate value in astronomy.

On February 7 Assistant Astronomer Littell was assigned to this instrument as a regular observer, and observations were begun on February 13. The observation list comprised 135 stars selected from Gill's Zodiacal Catalogue, for the special purpose of heliometer observations of the planets Neptune, Jupiter, Saturn, and Mars. This work is well advanced toward completion, and the results will be published as soon as practicable in the current astronomical journals. A further list of 45 ephemeris stars, distributed widely in declination, has been observed in both right ascension and declination and in both positions of the clamp, with a view of testing the performance of the instrument more thoroughly. The observations in declination are made with the fixed pair of threads in the field of the telescope by moving the telescope with the slow-motion screw so as to bring the star midway between the pair of threads, which are 9 seconds apart. All observations in declination have been referred to the nadir point, which was observed in an analogous manner, no use being made of the micrometer screw, as is the custom with the 9-inch transit circle. When an assistant is present both circles are read, and an observation in declination consists of two settings on the star and a reading of four microscopes on each of the two circles. When both circles are read in this manner the probable accidental error at moderate zenith distances of a single observation in declination is ± 0″.22.

This instrument is made entirely of steel and mounted very solidly, so that the constants might reasonably be expected to be unusually steady. In the case of the level and collimation this expectation has been realized, but not in the case of the azimuth. Both the collimation and the level are remarkably uniform, excepting that on one or two occasions the latter has shown slight though anomalous changes. A series of experiments made in November, 1899, showed that the variation of the azimuth keeps pace regularly with the variation of the temperature of the steel in the microscope bearers on which the pivots rest. This variation is not, however, a linear function of the temperature, but is less per degree at low than at high temperatures. The change of azimuth per degree of temperature (Fahrenheit) during the earlier part of its use seems to have been $0^s.032$. Since the instrument is provided with a meridian mark to the north, this variation of the azimuth has been productive principally of inconvenience rather than inaccurate work; but the change is too great to make the instrument a suitable one for fundamental work. The instrument will in the near future be entirely dismounted and a careful investigation made in the hope of finding the source of this variation.

Except during the month of May, when work was temporarily suspended on account of the absence of both Professor Updegraff and Mr. Littell in connection with the total eclipse of May 28, observations were made on almost every clear night from February 13 to the end of the year covered by this report. Naturally much labor has been expended on the determination and investigation of the constants of the instrument. A summary of observations made during the period February, 1900, to June, 1900, follows:

Observations of stars.

Observations of Polaris for latitude and azimuth	26
Zero and ephemeris stars	395
Zodiacal catalogue stars	744
Thread interval stars	72
Total	1,237

Determinations of instrumental constants.

Determination of collimation	99
Determination of azimuth of instrument	195
Determination of level	145
Determination of azimuth of mark	26
Determination of error of runs	52
Determination of nadir points	268
Total	785

It is intended to use this instrument principally in observing the fixed stars, and to adapt it, as far as may be possible under the conditions, to fundamental work of a high degree of accuracy.

For the immediate future this work will consist of the determination of the positions of 205 zero stars for the catalogue of 2,798 zodiacal stars arranged by Sir David Gill, director of the Royal Observatory, Cape of Good Hope, in accordance with the resolutions of the Conference on Fundamental Stars, held in Paris in 1896. There will also be included, as in the past, stars from Newcomb's Fundamental Catalogue, for the purpose of the investigation of the instrument and as the basis to which the Gill zero stars will be reduced.

THE 12-INCH EQUATORIAL TELESCOPE.

This instrument was in charge of Professor See from July 16 until December 17, 1899, since which date I have had it under my general charge, in order to test for myself the complaints of its unsatisfactory performance by those who have observed with it. It has been used, as in the past, for observations of comets, asteroids. and other miscellaneous objects. Those made by Professor See, and which were published in the Astronomische Nachrichten, No. 3626, were as follows:

Antiope (90), 7; Leto (88), 5; Elvira (277), 3; Minerva (93), 8; Comet V 1899, 2.

A careful investigation of the micrometer screw was published in the same paper, giving the value of a revolution as follows:

366 transits of circumpolar stars	22″. 890
120 measures on four stars of the Pleiades	22″. 879
Mean	22″. 885±0″. 002

for scale reading 462 and temperature 50° F.

A careful investigation of the instrument convinces me that its efficiency would be greatly increased by a general change in the details of its mountings and accessories. Plans are now under discussion, submitted by the firm of Fauth & Co., its makers, which it is hoped will remedy the principal defects. The proposed changes consist of:

1. The separation and mounting on separate axes of the two wheels for quick motion, which now revolve on a common axis, so that frequently motion in one coordinate produces a change in the other.

2. Separation of the clamping and slow-motion handles on the tube, which now operate at times only with the application of considerable force and with the result of unclamping the instrument in right ascension.

3. Remodeling of the head casting, which is necessary to effect changes above mentioned and give a more direct and positive clamping and slow motion in right ascension.

THE PRIME VERTICAL TRANSIT INSTRUMENT.

[Assistant Astronomer GEORGE A. HILL, in charge.]

The work on this instrument has been devoted to observations of α Lyræ and a small list of suitable stars for the purpose of investigating the variation of latitude and the constants of nutation and aberration. The number of observations is as follows:

α Lyrae	89
Other stars	75

A careful investigation of the level constant, with a special reference to the coincidence and parallelism of the axis of the pivots, is in progress, but the material is not yet sufficient to determine whether any defect exists in regard to this which is of sufficient magnitude to affect the observations. All the observations are reduced up to date, and, together with the observations on the alt-azimuth instrument for the same purpose, have been furnished in manuscript up to January, 1900, to the Centralbureau der Internationalen Erdmessung, to be used by Professor Albrecht in his annual memoir on the condition of the investigations of the latitude variation at the end of the year 1899.

THE 5-INCH STEEL ALT-AZIMUTH INSTRUMENT.

[Assistant Astronomer GEORGE A. HILL, in charge.]

This instrument is used principally as a zenith telescope for observations of latitude by Talcott's method and the declinations of the stars of the American Ephemeris. Of the former there have been made 86 observations of α Lyræ and 3 of miscellaneous stars, which are reduced up to date, and the results to January, 1900, together with the material from the prime vertical instrument, sent to Professor Albrecht. Of the declinations of Ephemeris stars 330 observations have been made, and the reductions are completed up to the end of the calendar year. The results have not yet been subjected to sufficient study to determine the quality of the instrument for obtaining absolute declinations, for which purpose the general form of the mounting is admirably adapted. When its usefulness in this field is established I propose to separate the work of the two instruments and employ more observers in this important line of observation. I have not thought it expedient to attempt this until the arrears of publication are brought up—a task on which all the available force of the Observatory is now concentrated.

THE 40-FOOT PHOTOHELIOGRAPH.

[Photographer GEORGE H. PETERS, in charge.]

The series of daily photographs of the sun has been continued, weather permitting, except after April 2, when they were interrupted by the preparations for the observations of the total eclipse in May. Negatives were obtained on 81 days, showing sun spots on 18, distributed as follows: Two in September, 2 in December, 5 in January, 5 in February, 3 in March, and 1 in April. Visual observations of the sun in May indicate the same low state of solar activity.

In December the glass reticule plate, used in the transit of Venus observations for determining any possible distortion of the film, but which was of no value for sun-spot photographs, was removed, as the thick glass plate placed about a quarter of an inch in front of the focal plane of the object glass was a serious obstacle to good definition, on account of the multiple reflections of light forming the sun's image between its plane surfaces. At the same time the dry plate was substituted for the wet collodion process previously used, and the plates backed. Upon focusing the apparatus anew a great gain was apparent in the definition of the lens and the amount of detail shown on the solar surface, so that it is now possible to obtain a negative showing a great deal of detail in the spots and faculæ.

INSTRUMENTAL CHANGES.

March 5, 1900, the Clark micrometer No. 2, which had been provided by Warner & Swasey with a modern and efficient electric illumination, was installed on the 26-inch equatorial in place of the old Clark micrometer. The latter had been in service since 1873, but though still serviceable was provided with illumination only by a small hand lamp held by an assistant. This method was not only inconvenient, but caused an unsymmetrical illumination which might produce systematic error in observations. The new micrometer was made by Mr. George Clark in 1874, but has since been used only in the determination of its constants, and represents the finest workmanship of a gifted mechanic. The screw was investigated by Professor Holden in 1876 (Washington Observations, 1877, Appendix I), and the value of a revolution fixed at 9″.300. The preliminary value adopted by Professor See from transit of circumpolar stars and measures on Atlas and Pleione of the Pleiades is 9″.928 ± 0″.001. Thus far his investigation shows no temperature coefficient, although the observations for this are not yet completed. Experience with this instrument in the past indicates that this will be an inappreciable quantity. The illumination by a small 2-candle electric lamp with current from seven Edison-Lalande cells is symmetrical, steady, and capable of adjustment to any desired color or intensity. While the box containing the lamp becomes noticeably warm, it is so insulated from the micrometer box that it can hardly produce any appreciable effect on the micrometer screw.

Both the 6 and 9 inch transit circles are to be provided with mirrors or meridian marks to the south, duplicates of the ones already to the north of the respective instruments, except that in case of the 6-inch the distance from the instrument on account of the nature of the land toward the south can be only about 175 feet instead of 380. The lenses, mountings, and meridian marks were ordered in April from Messrs. Warner & Swasey, and will be installed immediately upon their arrival, which is promised by the end of August at the latest. The object of this additional mark to the south is to eliminate the liability of systematic errors in the azimuth due to error of assumed collimation, which will affect the azimuths resulting from the north and south marks with opposite signs.

THE SOLAR ECLIPSE OF MAY 28, 1900.

As soon as it was ascertained that Congress had appropriated money for carrying out the observations for this important event, I began the formation of general plans for the work, including alterations in instruments already possessed by the Observatory, and designs for new ones. In the formation of parties, the selection of the most important lines of investigation, and suitable instruments for the purpose, the general interest of scientists in the event was recognized by inviting the cooperation of specialists in the spectroscopic and physical research, and it is gratifying to state that this invitation was generally accepted, so that a considerable portion of the actual work of preparing for and observing the eclipse was shared by many scientific institutions of the country.

To avoid as far as practicable unfavorable weather, two widely separated stations were selected, one at Pinehurst, N. C., and one at Barnesville, Ga., both near the central line of totality. For certain advantages in spectroscopic work a third station was chosen at Experiment, Ga., near the northern limit of the shadow path. Notwithstanding the efforts to get all apparatus in readiness so that at least a month would be available for erecting and testing the instruments, the delays and failures of instrument makers prevented the erection of some of the important ones until only four or five days before the eclipse. This delay, which caused the failure of some of the most carefully planned instruments, might have been avoided if the Observatory were supplied with a small machine shop, the possession of which enabled other expeditions to occupy their stations fully a month before the eclipse. The general programme of observations comprised the following objects:

1. Establishment of accurate geographical position of stations.
2. Sketches of corona, both naked eye and telescopic, and telescopic study of physical structure.
3. Photographs of corona.
4. Spectroscopic observations of "reversing layer" and corona, both visual and photographic.
5. Polariscopic observations of corona, visual and photographic.
6. Observations of contacts and determination of the limits of the shadow path.
7. Observations of "shadow bands" and general phenomena.

The instruments to carry out this programme were, from the nature of the case, often expressly made, and yet were required to be mounted with such care in rude temporary shelters that the brief time of eighty or ninety seconds might be utilized to secure with certainty observations of the greatest delicacy and precision. The endeavor was made to devise instruments and methods which would enable us to make a distinct advance on previous eclipse work. In several lines this was successfully done, notably in the matter of spectroscopes, in which gratings were generally substituted for glass prisms. Two of these, with several quartz lenses, were purchased with special reference to eclipse work, and will form a valuable addition to our apparatus for future work in this line, as well as in the investigation of the spectra of stars and motion in the line of sight.

While there were failures with some of the instruments, due to lack of time for properly mounting and testing them, I am happy to state that the programme was, as a whole, successfully carried out, and valuable material secured which is now in process of study and investigation. As it is proposed to publish within a few months a detailed report upon the eclipse expeditions and results, a fuller statement is not thought desirable.

In this connection your attention is invited to the importance of an early appropriation for the observations of the total eclipse of May 17, 1901, which is in many respects the most remarkable of the century, on account of the long duration of totality of six and one-half minutes and the high altitude of the sun. It can be observed to advantage only in the islands of Sumatra and Borneo, and perhaps a few other small islands of the East Indies. The Observatory has an unusual advantage on account of the facilities which may be afforded by its transport service and the presence of many naval vessels in that region. The special instrumental equipment now on hand and the experience acquired in the recent eclipse place this Observatory in a position ot do great service to science, which the expense involved will almost preclude private expeditions from assuming. Already Holland is preparing for its observations, and Great Britain will most probably follow its custom of sending an expedition in a naval vessel.

STANDARD CLOCK.

Preparations are now in progress for installing a standard clock in a hermetically sealed case to be kept in a double-wall chamber at a constant temperature. The device for keeping the temperature constant is entirely similar to that now employed so successfully in the temperature room for testing chronometers. I consider this subject as one of the most important for the future of the fundamental work of the Observatory, and no pains or expense ought to be spared in securing the best possible performance of a standard clock under the conditions above described. I regret that the preparations for the eclipse so completely occupied the resources of the Observatory that this important matter has had to be laid aside until the present time.

PUBLICATIONS.

The volumes for 1891 and 1892 are still in the hands of the Government Printer awaiting some changes in, or additions to, the appendix for 1891, containing "Observations of the transit of Venus. December, 1874, part 2." These changes are to be made by my predecessor in this office, now on the retired list, by virtue of an arrangement made previous to his retirement with the Superintendent of the Observatory. As I was not consulted by my predecessor in regard to this arrangement, nor given any information concerning the nature of the further work to be done on the appendix mentioned, I am not in a position to accept the responsibility for the future of those two volumes.

The future publications of the Observatory, other than these, will be continued as Washington Observations, second series, beginning with the removal to the new Observatory in 1893. The volumes of this series will be classified, and each one will contain only the material pertaining to its title. As far as planned, they will be as follows:

Volume I, Observations of the Sun, Moon, and Planets, 1894–1899.

Volumes II and III, Observations of the Southern Zones, −13° 50′ to −18° 10′.

Volume IV, Zone Catalogue of Stars, −13° 50′ to −18° 10′.

The other volumes will be devoted to the work on the different instruments, as well as some valuable material extending back into the early history of the Observatory.

With the increased computing force provided by the last session of Congress, it is intended to prepare for publication, at an early date, the Washington Zones, made during the years 1845–1851, but the current work will not be neglected in order to accomplish this task, so important to the reputation of the Observatory. The observations of the Gilliss Zones, made in 1850–1852, will, after that, be taken in hand. There is no doubt as to the advisability and desirability of publishing these zones, not only on account of their value, but as a memento to the activity of the late Captain Gilliss, whose death prevented their timely publication.

Very respectfully,

STIMSON J. BROWN,
Professor of Mathematics, U. S. N., Astronomical Director.

The SUPERINTENDENT, U. S. NAVAL OBSERVATORY,
Georgetown Heights, D. C.

DEPARTMENTS OF NAUTICAL INSTRUMENTS, AND OF THE GENERAL STOREKEEPER.

SIR: The general storekeeper's department has kept up the preparation of requisitions for the purchase of new articles and for repairs to old ones, the inspection of stores, and the issue to ships and naval stations.

The appended list shows the purchases of new stores and of the issues made in the ordinary routine during the fiscal year ending June 30, 1900:

Stores received and issued by general storekeeper's department.

	Received.	Issued.
Artificial horizons		19
Bottles mercury		1
Sextants:		
High-grade	30	16
Squadron angles		18
Hydrographic	20	46
Spare glass for	24	61
Octants		13
Parallel rulers:		
Sigsbee		9
Ordinary		68
Clocks, deck	87	50
No. 2	100	52
Boat	124	26
Protractors, three-arm		19
Drawing instruments, boxes	25	19
Dividers, navigator's		19
Tapes, steel		14
Thermometers:		
Maximum and minimum	72	26
Air and water	335	212
Psychrometers	44	14
Spyglasses:		
Low-power	30	30
Medium-power	100	30
High-power	50	23
Officer of deck		35
Binoculars:		
Day	50	87
Night	100	122
Barometers, aneroid	66	22
Clinometers:		
Hicks	50	26
Fluid, bottles	100	54
Fluid, droppers	100	12
Reading glass, captain's		13
Splines and weights		15
T squares		9
Automatic tide gauges	3	3
Magnetometers	3	1
Dip circles	3	1
Telemeters rods	4	4
Transit, surveyor's		1
Transits and zenith telescope combined	1	2
Chronographs	1	2
Theodolites		2

Stores received and issued by general storekeeper's department—Continued.

	Received.	Issued.
Plane table		1
Triangle		1
Steel scale, standard	1	1
Sounding tubes:		
Tanners'	488	488
Cases	24	24
Shields	49	49
Scales	24	24

In addition to the ordinary routine work, this department has been charged with the assembling, inspecting, marking, and packing of six complete outfits for hydrographic survey in the Philippine Islands, and has under way four additional outfits for hydrographic work and two outfits for the telegraphic determination of longitude. The labor connected with the preparation of these outfits has been far greater than the routine work of former years, and as it seems likely that the Bureau of Equipment will lay out more surveying work in the future than it has in the past, I beg to recommend a reorganization of the working force of this department of the Observatory. Heretofore the books have been kept by the Superintendent's clerk when he could find time from other duties; and all that relates to the handling, packing, marking, and custody of stores to one, and sometimes two, unskilled laborers from the grounds.

The aggregate value of the instruments purchased and received from navy-yards and other sources during the year amounted to $51,087.73. There were made 136 shipments of instruments, the invoice value of which amounted to $40,123.08.

There has been no personnel belonging to the department except the head of the department. A better organized and more responsible force is urgently needed if the work of the department is to be performed in an efficient manner. It has been impossible in the last few years to get as many line officers assigned to duty here as in former years, and the force will apparently have to be made up of civilians. I recommend as a suitable force to assist the head of the department:

1 clerk and bookkeeper.
1 skilled laborer.
1 unskilled laborer.
1 computer to determine the corrections of navigating and surveying instruments.

This latter work could be paid for per diem under "Increase of the Navy" according to the number of hours employed.

Very respectfully,

B. W. Hodges,
Lieutenant-Commander, U. S. N.,
Head of Department and General Storekeeper.

Department of Chronometers and Time Service.

Sir: During the early part of the year twelve new chronometers were purchased without trial. Of those that passed through the trial seven were purchased. Five standards and three hacks were reported during the year, which were either purchased with ships or captured during the Spanish war.

The following table includes the chronometers at Mare Island, Cal., in addition to the same for the Observatory, and shows the number received and issued during the year:

	Purchased—		Returned from—			Condemned to be hacks.	Converted from standards.	Issued to—			Condemned to be hacks.	Converted from standards.
	New.	With ships.	Ships.	Shore stations.	Makers.			Ships.	Shore stations.	Makers.		
M. T. standards	19	5	49	1	48	0	0	62	2	38	1	5
M. T. hacks	0	3	15	0	16	1	0	22	0	13	0	0
M. T. brk. circ	0	0	0	1	1	0	1	0	3	0	0	0
Sid. brk. circ	0	0	0	1	4	0	4	1	1	6	0	0
Sid. standards	0	0	1	1	0	0	0	1	0	0	0	0
Thermometric	0	0	0	0	2	0	0	0	0	0	0	0

The following table shows the present location of all the seagoing chronometers belonging to the Navy:

	In service, afloat.	At Mare Island.	At shore stations.	Ready for issue.	Undergoing repairs.	Total.
M. T. standards	215	24	10	56	32	337
M. T. hacks	61	7	19	10	4	101
M. T. brk. circ	1	1	6	0	0	8
Sid. brk. circ	3	2	5	1	4	15
Sid. standards	0	1	0	1	0	2
Thermometric	0	0	4	0	0	4
Pocket	0	0	0	5	1	6
Total	280	35	44	70	44	473

Besides the above, there are 26 worn-out hacks which are condemned for use at the Observatory. But few of these are of any use. Twenty-one chronometers are held at the Observatory on account of their historical interest.

On July 12, 1899, a requisition was made for the purchase of 12 standard chronometers after a competitive trial, and notice was sent to the principal firms of chronometer makers in the United States.

Only two firms entered chronometers under the notice, the other firms being deterred by the fact that during the war with Spain they had sold off their stock of chronometers and did not have any that they themselves considered fit for competition.

Of the two firms that competed, H. H. Heinrich, of New York, entered 11, and Wm. Bond & Son, of Boston, entered 4. Of the 15 under trial, one—H. H. Heinrich, No. 1037—had a trial number small enough to be accepted under the specifications, at the price of $330; but with the consent of the Bureau of Equipment 6 others—H. H. Heinrich, Nos. 1052, 1051, 1045, and Wm. Bond & Son, Nos. 551, 544, and 534, were purchased at a reduced price of $250 each.

The poor showing made by the chronometers was ascribed by the makers to the fact that the chronometers were new and unseasoned. In addition to the chronometers entered as above by the makers, 34 of the Bureau's chronometers were put through the same test for the determination of new rate curves.

The temperature-room trial began on December 19, 1899, and lasted until March 17, 1900. The apparatus for cooling, heating, and regulating the temperature gave satisfactory results.

The chronometer-room trial began on March 20 and lasted to June 12, 1900.

The following table shows the detailed results of the trial:

Relative number.	Time			Dec. 19 to Dec. 26	Dec. 28 to Jan. 4	Jan. 7 to Jan. 14	Jan. 18 to Jan. 25	Jan. 27 to Feb. 3	Feb. 5 to Feb. 12	Feb. 15 to Feb. 21	Feb. 26 to Mar. 5	Mar. 10 to Mar. 17	Mar. 20 to Mar. 27	Mar. 27 to Apr. 3	Apr. 3 to Apr. 10
	Temperature, Fahrenheit ... degrees			45.8	54.9	70.0	85.0	90.0	85.1	69.9	55.2	45.3	65.8	64.5	66.5
	Relative humidity ... per cent			68	68	70	68	71	70	71	66	72	51	52	52
	Repaired by—	Chronometer number.	Maker.												
1		2941	John Bliss & Co	−1.47	−2.63	−3.26	−2.74	−2.16	−2.61	−3.45	−2.96	−1.89	−4.06	−4.16	−4.30
2	Bond	49238	Dent	+2.29	+1.59	+1.31	+1.53	+1.53	+1.30	+1.18	+1.10	+2.03	+0.69	+1.03	+1.27
3		554	Wm. Bond & Son	+0.20	−1.29	−2.21	−1.57	−1.33	−1.61	−2.23	−1.47	−0.16	−2.24	−2.26	−2.47
4	Negus	1281	T. S. & J. D. Negus	....	+1.80	+1.46	+1.64	+2.27	+1.96	+1.52	+2.66	+3.80	+1.99	+2.01	+1.91
5	Bond	548	Wm. Bond & Son	+2.00	+1.04	+0.66	+1.47	+2.07	+1.91	+1.23	+1.46	+2.77	+0.47	+0.36	+0.24
6		558	do	−1.63	−2.10	−1.86	−0.53	+0.36	−0.40	−1.83	−1.76	−0.51	−2.74	−2.69	−2.87
7		2934	John Bliss & Co	+0.41	−0.39	−0.93	−0.04	+0.81	+0.54	−0.12	+0.13	+0.99	−1.00	−0.97	−1.11
8	Negus	1850	T. S. & J. D. Negus	....	+0.44	−0.15	+0.31	+0.60	−0.17	−0.70	+0.53	+2.06	−0.17	−0.19	−0.40
9	Negus	1710	Clerk	+1.53	+0.47	+0.07	+0.71	+1.60	+1.37	+0.50	+0.90	+2.59	+0.09	+0.06	−0.11
10		556	Wm. Bond & Son	+0.77	−0.56	−1.79	−1.93	−1.21	−1.61	−2.15	−1.33	+0.37	−1.89	−1.86	−1.91
11	Negus	1074	T. S. & J. D. Negus	....	−0.06	−0.83	+0.23	+0.71	−0.01	−0.83	+0.23	+1.44	+0.11	+0.14	+0.10
12	Negus	1265	do	+0.96	−0.64	−1.29	−0.39	+0.06	−0.59	−1.65	−0.66	+0.73	−1.49	−1.56	−1.83
13		518	Wm. Bond & Son	+1.56	+0.13	−0.71	+0.19	+0.81	+0.53	−0.37	+0.57	+1.73	−0.29	−0.43	−0.73
14	Bond	221	do	−0.36	−0.03	−0.53	−0.11	−0.21	−0.47	−0.70	−0.90	+0.30	+0.73	+0.99	+0.99
15	Negus	1291	T. S. & J. D. Negus	+2.34	+1.43	+1.21	+2.51	+3.41	+3.01	+1.63	+1.89	+2.73	+1.26	+1.24	+1.21
16	Bond	218	Wm. Bond & Son	−0.59	−1.77	−2.10	−1.14	−0.47	−0.73	−1.27	−0.79	+0.16	−1.39	−1.43	−1.56
17	Bond	293	do	+0.86	−0.74	−1.71	−1.14	−0.61	−0.84	−0.90	+0.17	+1.73	−0.50	−0.16	−0.23
18	Negus	1655	T. S. & J. D. Negus	+2.79	+2.19	+2.71	+4.21	+2.85	+2.91	+2.92	+2.60	+3.04	+2.79	+2.81	+2.77
19		2937	John Bliss & Co	−3.71	−3.77	−3.43	−3.19	−2.40	−2.33	−2.53	−2.80	−3.09	−4.17	−4.64	−5.16
20		2949	do	−1.54	−2.86	−3.50	−2.83	−2.50	−2.66	−3.57	−3.26	−2.41	−4.44	−4.69	−5.00
21		557	Wm. Bond & Son	−3.00	−2.61	−1.41	−1.39	−1.31	−1.76	−2.28	−3.24	−3.81	−3.04	−2.79	−2.23
22		48831	Dent	−2.14	−0.87	−0.60	−0.90	−0.93	−1.04	−1.37	−2.46	−1.41	−2.67	−2.69	−2.73
23	Negus	725	T. S. & J. D. Negus	+2.50	+2.19	+1.29	+1.40	+1.50	+1.51	+1.53	+3.03	+4.40	+2.33	+2.17	+2.03
24	Heinrich	1016	H. H. Heinrich	+4.31	+3.86	+3.43	+2.54	+2.39	+2.60	+1.93	+2.83	+4.61	+2.84	+3.01	+2.96
25	Bliss	2829	John Bliss & Co	+5.39	+3.33	+0.77	+0.61	+0.70	+1.13	+1.67	+2.21	+3.51	+1.87	+1.70	+1.43
26	Bond	493	Wm. Bond & Son	−1.16	−1.24	−0.86	−0.14	+0.63	+0.41	−0.20	−1.80	+0.09	−0.36	−0.29	−0.33
27	Bond	2851	Frodsham	+2.03	−0.49	−0.36	+1.54	+3.01	+2.49	−0.17	0.00	+1.20	−0.60	−0.69	−0.64
28	Bliss	49461	Dent	+6.27	+3.54	+1.93	+1.71	+1.46	+1.49	+1.25	+2.40	+3.27	+2.29	+2.36	+1.96
29		553	Wm. Bond & Son	−1.37	−1.70	−3.26	−2.86	−1.16	−0.76	−1.45	−1.61	−1.30	0.00	+0.33	−0.01
30	Bliss	2860	John Bliss & Co	−0.77	−1.67	−1.86	−1.10	−0.70	−0.69	−2.62	−0.41	−0.49	−0.86	−0.81	−1.03
31	Bond	4667	Johannsen	−5.19	−4.59	−4.64	−4.21	−4.04	−3.13	−2.90	−3.40	−2.73	−3.14	−2.97	−2.73
32	Bond	272	Wm. Bond & Son	−1.09	−2.10	−0.97	+0.46	+1.20	+0.99	+1.25	−0.04	−0.81	−0.29	−0.36	−0.40
33		47667	Dent	−3.80	+0.31	+0.43	+0.74	+1.06	+0.99	+0.73	+0.36	−2.01	+0.50	−0.17	−0.46
34	Bond	555	Nieberg	+0.64	+0.86	−0.11	+4.27	+5.60	+5.77	+5.13	+3.96	+6.44	−0.81	+2.00	+2.39
1		1037	H. H. Heinrich	+2.71	+1.29	+0.11	+0.53	+0.60	+0.63	+0.55	+0.99	+2.34	−0.60	−0.40	−0.37
2		1041	do	+0.86	−0.27	−0.50	+0.76	+1.53	+1.06	−0.13	+0.57	+1.19	−0.56	−0.59	−0.69
3		1052	do	+0.10	−0.87	−1.43	−1.43	−1.26	−2.00	−2.50	−1.33	+0.01	−2.10	−1.86	−2.10
4		1051	do	+0.34	+0.69	+1.43	+2.71	+2.40	+2.27	+0.88	+1.03	+0.91	+1.06	+0.84	+0.87
5		551	Wm. Bond & Son	+3.43	+1.44	−0.07	−0.21	+0.27	+0.30	+0.52	+2.03	+4.10	+0.80	+0.91	+0.24

6	....	544	.....do	+0.53	+0.47	+0.96	+1.00	+3.31	+2.51	+0.73	+0.51	+0.87	+0.51	+0.43	+0.49
7	....	1045	H. H. Heinrich	+3.67	+2.23	+2.97	+3.90	+4.31	+3.67	+2.17	+2.41	+3.94	+2.06	+2.44	+2.27
8	....	534	Wm. Bond & Son	+1.57	−0.51	+0.31	+0.96	+1.03	+0.66	−0.10	+1.04	+1.74	+1.16	+0.96	+0.47
9	....	1048	H. H. Heinrich	+0.27	−0.54	−0.39	+1.04	+1.74	+1.69	+0.42	+1.06	+1.59	+0.49	+0.44	+0.06
10	....	1049	.....do	+0.29	−0.60	−1.40	−0.24	+0.71	+0.31	−0.78	−0.01	+2.03	+0.11	+0.29	+0.09
11	....	559	Wm. Bond & Son	+4.31	+2.51	+0.79	+0.60	+0.57	+0.34	−0.35	+1.23	+3.16	+0.51	+0.01	−0.43
12	....	1047	H. H. Heinrich	−0.26	−1.24	−3.11	−1.50	−0.50	−0.90	−1.58	−0.94	+0.40	−1.96	−1.83	−1.94
13	....	1044	.....do	+2.14	+0.36	−1.31	−1.11	−1.26	−2.16	−2.15	−1.30	+0.59	−2.10	−2.11	−2.19
14	....	1046	.....do	−1.09	−3.19	−5.61	−4.04	−3.16	−3.94	−4.48	−3.73	−3.13	−4.39	−4.36	−4.44
15	....	1050	.....do	+0.99	−0.60	+1.21	+0.59	+1.00	+0.10	+0.72	+1.79	+4.19	−0.07	−0.11	−0.30

Relative number.			Time	Apr. 10 to Apr. 17	Apr. 17 to Apr. 24	Apr. 24 to May 1	May 1 to May 8	May 8 to May 15	May 15 to May 22	May 22 to May 29	May 29 to June 5	June 5 to June 12	Temperature of compensation.	Temperature constant.	Trial number.
			Temperature, Fahrenheit............degrees..	70.0	78.1	75.9	71.3	68.8	72.4	68.6	70.1	72.9			
			Relative humidity..................per cent..	50	55	50	51	57	61	61	67	74			
	Repaired by—	Chronometer number.	Maker.										°		
1		2941	John Bliss & Co	−4.49	−4.34	−4.59	- 4.76	−4.84	−4.81	−4.91	−4.90	−4.89	69.3	+0.00270	10
2	Bond	49238	Dent	+1.06	+0.74	+1.13	+1.10	+1.49	+1.69	+1.67	+1.70	+1.50	67.9	+0.00062	10
3		554	Wm. Bond & Son	−2.59	−2.69	−2.69	−2.83	−2.94	−2.97	−2.94	−2.97	−3.06	71.1	+0.00327	15
4	Negus	1281	T. S. & J. D. Negus	+1.81	+1.89	+1.91	+1.86	+1.77	+1.71	+1.77	+1.63	+1.49	73.1	+0.00234	16
5	Bond	548	Wm. Bond & Son	+0.23	+0.90	+0.76	+0.43	+0.30	+0.69	+0.51	+0.50	+0.71	66.9	+0.00236	16
6		558	do	−2.80	−2.50	−2.61	−3.06	−3.09	−2.70	−2.70	−2.69	−2.43	61.4	+0.00288	19
7		2934	John Bliss & Co	−1.30	−1.04	−1.26	−1.29	−1.49	−1.43	−1.61	−1.74	−1.70	67.6	+0.00257	19
8	Negus	1850	T. S. & J. D. Negus	−0.67	−0.74	−0.94	−0.69	−0.90	−1.19	−1.16	−1.11	−1.10	72.2	+0.00310	19
9	Negus	1710	Clerk	−0.10	+0.23	−0.16	−0.37	−0.01	+0.04	+0.23	+0.03	−0.03	67.7	+0.00257	20
10		556	Wm. Bond & Son	−1.84	−2.03	- 2.00	−1.97	−1.74	−2.03	−2.11	−2.26	−2.36	75.1	+0.00274	20
11	Negus	1074	T. S. & J. D. Negus	+0.09	+0.19	+0.11	+0.03	−0.09	−0.17	−0.27	−0.40	−0.34	69.9	+0.00411	20
12	Negus	1265	do	−1.89	−1.81	--1.87	−2.11	−2.26	−2.26	−2.26	−2.37	−2.41	69.4	+0.00399	20
13		518	Wm. Bond & Son	−0.91	−0.57	−0.77	−0.89	−0.70	−0.90	−0.80	−0.71	−0.46	70.0	+0.00398	22
14	Bond	221	do	+1.49	+0.57	+0.16	+0.67	+1.64	+1.53	+1.66	+1.24	+0.94	67.4	+0.00107	22
15	Negus	1291	T. S. & J. D. Negus	+1.36	+1.56	+1.51	+1.20	+1.13	+1.19	+1.09	+1.07	+1.14	64.8	+0.00350	22
16	Bond	218	Wm. Bond & Son	−1.61	−1.47	−1.40	−1.97	−1.70	−1.79	−1.59	−1.64	−1.63	67.8	+0.00250	24
17	Bond	293	do	−0.27	−0.59	−0.46	−0.33	−0.19	−0.61	−0.47	−0.76	−1.00	74.1	+0.00300	28
18	Negus	1655	T. S. & J. D. Negus	+2.81	+2.81	+2.93	+2.80	+2.70	+2.86	+2.81	+2.77	+2.77	42.1	+0.00069	31
19		2937	John Bliss & Co	−5.37	−5.07	−5.06	−5.89	−5.81	−5.93	−5.59	−5.74	−5.79	108.3	−0.00022	33
20		2949	do	−5.21	−5.10	−5.37	−5.43	−5.09	−6.33	−5.76	−5.66	−5.56	68.2	+0.00285	33
21		557	Wm. Bond & Son	−1.81	−1.89	−2.04	−1.73	−1.90	−1.64	−1.99	−2.43	−3.14	82.7	−0.00176	34
22		48831	Dent	−2.77	−2.21	−2.44	−2.47	−2.51	−2.31	−2.40	−2.30	−2.21	77.7	−0.00154	38
23	Negus	725	T. S. & J. D. Negus	+1.91	+1.33	+1.61	+1.57	+1.70	+1.00	+1.01	+0.93	+0.73	76.9	+0.00278	46
24	Heinrich	1016	H. H. Heinrich	+2.51	+1.97	+1.23	+1.71	+2.03	+0.91	+0.63	+0.71	+1.19	80.4	+0.00123	50
25	Bliss	2829	John Bliss & Co	+1.57	+1.04	+0.41	+0.17	+0.49	+1.14	+1.20	+0.93	+1.39	81.8	+0.00269	53
26	Bond	493	Wm. Bond & Son	−0.53	−0.36	−0.44	−0.60	−0.74	−0.60	−0.77	−0.79	−0.71	107.6	−0.00074	56
27	Bond	2851	Frodsham	−0.64	−0.60	−0.97	−1.00	−1.03	−0.96	−0.94	−0.83	−0.70	62.6	+0.00480	58
28	Bliss	49461	Dent	+1.94	+2.03	+2.15	+1.70	+1.77	+1.19	+1.44	+1.53	+1.09	77.4	+0.00311	60
29		553	Wm. Bond & Son	−0.07	+0.11	−0.11	−0.50	−0.41	−0.21	−0.06	−0.61	−0.74	70.9	+0.00279	74
30	Bliss	2860	John Bliss & Co	−1.27	−1.10	−1.04	−1.16	−1.44	−1.50	−1.44	−1.64	−1.79	76.2	+0.00565	82
31	Bond	4667	Johannsen	−3.09	−3.15	−2.97	−2.77	−2.61	−3.47	−2.97	−3.86	−4.61	91.1	−0.00027	88
32	Bond	272	Wm. Bond & Son	−0.34	+0.10	+0.31	−0.66	−0.66	−0.29	−0.26	−0.16	+0.11	91.4	−0.00140	99
33		47667	Dent	−0.41	+0.11	+0.20	−0.17	+1.27	+0.37	+0.01	+0.13	−0.17	−81.6	+0.00006	127
34	Bond	555	Nieberg	+1.80	+2.10	+1.77	+1.50	+1.94	+1.90	+1.41	+2.13	+1.90	61.5	+0.00509	482
1		1037	H. H. Heinrich	−0.51	−0.50	−0.13	−0.29	−0.37	−0.17	−0.34	−0.36	−0.54	74.0	+0.00236	16
2		1041	do	−0.59	....	−0.39	−0.53	....	−0.61	−0.66	−0.71	−0.60	66.7	+0.00378	25
3		1052	do	−2.11	−1.96	−2.74	−2.61	−2.59	−2.39	- 2.40	−2.41	−2.93	74.2	+0.00246	26
4		1051	do	+0.96	+1.00	+1.63	+1.31	+0.49	+1.43	+0.80	+1.03	+1.19	58.0	+0.00226	27

5	....	551	Wm. Bond & Son	−0.23	−0.69	−0.93	−0.16	−0.34	−0.50	−0.40	−0.44	−0.73	79.6	+0.00298	30
6	....	544	.....do	+0.90	+1.54	+1.20	+0.67	+0.41	+0.83	+0.49	+0.49	+0.54	53.0	+0.00124	32
7	....	1045	H. H. Heinrich	+1.87	+1.99	+1.76	+1.67	+1.34	+1.43	+1.20	+1.47	+1.89	58.5	+0.00212	35
8	....	534	Wm. Bond & Son	+0.70	+0.59	+0.54	−0.11	+0.03	+0.17	+0.63	+0.31	+0.16	65.2	+0.00194	36
9	....	1048	H. H. Heinrich	+0.24	+0.64	−0.19	−0.20	−0.57	−0.19	+0.09	+0.04	−0.04	64.8	+0.00350	50
10	....	1049	.....do	+0.41	+1.03	+1.21	+0.80	+0.41	+0.93	+0.84	+0.67	+1.69	68.7	+0.00426	53
11	....	559	Wm. Bond & Son	−0.43	−0.99	−0.84	−0.71	−0.61	−1.10	−1.03	−0.87	−1.00	75.5	+0.00424	56
12	....	1047	H. H. Heinrich	−1.91	−2.03	−2.21	−2.06	−1.87	−1.84	−1.87	−2.01	−2.03	70.4	+0.00533	58
13	....	1044	.....do	−2.20	−2.84	−2.53	−2.19	−2.51	−2.79	−2.50	−2.59	−2.71	76.5	+0.00302	59
14	....	1046	.....do	−4.24	−3.89	−3.47	−3.47	−3.70	−3.34	−3.49	−3.54	−3.00	71.6	+0.00585	81
15	....	1050	.....do	−0.49	−0.81	−3.29	−1.34	−1.33	−1.11	−0.90	−0.90	−1.29	68.0	−0.00219	236

WATCHES.

The following table shows the number of stop and comparing watches:

	Issued.	Received.	Repaired.	On hand.	Held for repairs.
Comparing	24	17	5	28	15
Stop	27	11	4	8	6

During the year two torpedo-boat watches were issued; two remain on hand; one is ready for issue, and one is held for repairs.

THERMOMETERS.

During the year 26 maximum and minimum thermometers have been issued to ships and 81 are now ready for issue. Seventy-two have been purchased and four have been returned from ships.

THE TIME SERVICE.

During the year 156 observations for time were made. The three standard clocks and the two clocks for transmitting noon signals have performed fairly well. Noon signals were sent out every day in the year except Sundays. The average error for the year of noon signals (seventy-fifth meridian time) was 0.11 seconds.

Very respectfully,

B. W. Hodges,
Lieutenant-Commander, U. S. N., Head of Department.

Report of the Director of the Nautical Almanac.

Nautical Almanac Office,
United States Naval Observatory,
Washington, D. C., August 13, 1900.

Sir: I have the honor to submit the following report respecting the operations of the Nautical Almanac Office for the fiscal year ending June 30, 1900:

PRINTING.

The books published during the year were received from the Government Printing Office on the following-named dates: American Nautical Almanac for 1900, second edition, July 5, 1899; Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac, volume 7, part 4, Tables of Neptune, July 17, 1899; American Ephemeris and Nautical Almanac for 1902, first edition, August 8, 1899; The Pacific Coaster's Nautical Almanac for 1900, first edition, September 8, 1899; Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac, volume 7, part 3, Tables of Uranus, September 28, 1899; the American Ephemeris and Nautical Almanac for 1900, second edition, December 18, 1899; the American Nautical Almanac for 1901, second edition, January 5, 1900; the American Nautical Almanac for 1903, first edition, March 13, 1900; the American Ephemeris and Nautical Almanac for 1903, first edition, April 21, 1900; the American Nautical Almanac for 1900, third edition, May 1, 1900; Supplement to the American Ephemeris and Nautical Almanac for 1900, entitled "Total Eclipse of the Sun, May 28, 1900," May 13, 1900.

DISTRIBUTION OF PUBLICATIONS.

During the fiscal year ending June 30, 1900, the sale and distribution of publications were as follows:

Title.	Sold.	Distributed.	Bureau of Equipment.	Public service.	Total.
American Ephemeris	958	359	233	591	2,141
American Nautical Almanac	2,152	....	61	491	2,704
Pacific Coaster's Almanac	1,400	....	7	8	1,415
Astronomical Papers	102	387	3	27	519

The proceeds of the above sales amounted to $1,844.46, and in compliance with law, that money has been deposited to the credit of the Treasurer of the United States, on account of public printing and binding.

THE AMERICAN EPHEMERIS.

The law authorizing the publication of the American Ephemeris contemplates the issue of each volume three years in advance of its date, but, as mentioned in the report for the year 1899, the extra work incident to the preparation of a series of tables of the major planets of the solar system retarded the Ephemeris to such an extent that the first edition of the volume for 1901 was not received from the Government Printing Office until April 5, 1899. Every available computer was taken from other work and placed on the Ephemeris to bring it up to the point required by law. By this means the first edition of the Ephemeris of 1902 was received on August 9, 1899, and the volume for 1903 was issued in April, 1900. The work on 1904 is so far advanced that this office can give every assurance that 1904 will be issued by January 1, 1901, making this publication completed full three years in advance of its date. All of the Almanac and three-fourths of the Ephemeris of 1904 are already in type.

The Pacific Coaster's Almanac for 1901 is now in type, and will be published before the end of August, thus making a considerable advance in the date of this publication.

The changes made in the Ephemeris for 1903, as mentioned in the former report, are continued in the Ephemeris for 1904.

NEW TABLES OF THE PLANETS.

The Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac, volume 7, part 3, Tables of Uranus, were issued September 28, 1899, and the Tables of Neptune, volume 7, part 4, were issued July 17, 1899.

NEW INVESTIGATIONS.

The formation of a catalogue of about 2,500 zodiacal stars, mentioned in the former report as having been begun, is now well advanced, and should be finished and issued by the end of the next fiscal year.

The revision of the elements used in the American Ephemeris for the outer planets of the solar system has been continued. This work, as stated in the former report of this office, was confined to the satellites of Mars and to the fifth satellite of Jupiter. It has since been extended to the reduction of several hundred observations for the determination of new elements of the seven inner satellites of Saturn.

These computations are not progressing as rapidly as I would wish, nearly the whole force being confined to the work on the Ephemeris, coupled with the fact that this office has been shorthanded from death or resignations of assistants since February, 1900.

Very respectfully,

HENRY D. TODD,
Professor of Mathematics, U. S. N., Director Nautical Almanac.

The SUPERINTENDENT U. S. NAVAL OBSERVATORY,
Georgetown Heights, D. C.

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